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Research Article

Phytotoxicity of Spent Oil and Phytoremediation Potential of *Acacia mangium* Willd on Spent Oil Contaminated Soil

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Abstract

Acacia mangium is a promising, fast growing evergreen leguminous tree native to tropical rain forests; its success is due to its extremely vigorous growth rate, tolerance to low nutrient soils and ability to grow reasonably well where competition is severe. However, its ability to survive in severe oil contaminating environment and its potential to phyto remediate oil contamination needs to be investigated. This study investigated the phytotoxicity of spent oil on *Acacia mangium* and its potential in the phytoremediation of soil contaminated with spent oil in a two (2) months pot experiment. Two (2) kg of potted top soil collected within Federal college of Forestry, Ibadan premises was contaminated with varying volume (treatment) of spent oil (T_1-0ml, T_2-50ml, T_3-150ml and T_4-250ml) replicated five (5) times, seedlings of *Acacia mangium* were transplanted into the pots and growth parameters such as plant height, stem girth and number of leaves was measured on weekly basis for eight (8) weeks, while pre planting and post planting total petroleum hydrocarbon (TPH) concentration of the soil was determined using standard methods and compared. The result shows a pre planting TPH of 0.57%, 3.23%, 13.00% and 17.57% for treatments 1, 2, 3 and 4 respectively, while comparable growth rate in plant height was observed across the treatments with T_2 having the highest height after 8 weeks while T_3 had the least height. No significant difference between the treatments at $p < 0.05$; in stem girth, T_1 had the highest while T_3 had the least which is not significantly different at $p < 0.05$; while treatments 1, 2 and 4 had comparable number of leaves which is significantly different from T3 which had the lowest number of leaves. *Acacia mangium* contributed to a significant removal of 92.98%, 66.56%, 88.85% and 88.73% of TPH present in the pre-planting soil from T_1, T_2, T_3 and T_4 respectively. The study further confirms the ability of *Acacia mangium* to withstand adverse condition and could thus be candidate for the phytoremediation of oil spill soils.

Keywords: Phytoremediation; *Acacia mangium*

Introduction

The contamination of soil by spent lubricating oil from automobiles is a growing concern in many countries in Asian and Africa [1], this is a common phenomenon in every automobile repair workshop in many places in Nigeria where some of the lands are temporarily occupied for such purpose, with the attendant indiscriminate disposal of spent lubricating oil in the surrounding soil [2,3]. The adverse effect of discharge of spent lubricating oil and crude oil spill related contaminants into the soil had been reported by several authors [2,4,5,6,7], thus it is necessary to find a way to clean up the soil in the event of reclamation of such land for human habitation. Different treatment methods have been proposed to rehabilitate contaminated soil many of which have high cost implication however, phytoremediation a strategy that utilizes plants to degrade, stabilize or remove contaminants from the soil, offers an environmentally friendly, cost effective approach for the remediation of a wide range of toxic substances in the soil environment [1,3,8].

Acacia mangium Willd. belongs to the family Leguminosae. It is a promising, fast growing evergreen leguminous tree native to tropical rain forests of Australia, Papua New Guinea and Indonesia [9]. It is a major plantation species in the humid tropical lowlands of Asia [10]. Its success is due to its extremely vigorous growth rate [11], tolerance of highly acidic, low nutrient soils and ability

to grow reasonably well where competition is severe, relative freedom from disease and ease of establishment in cultivation.

The fast growing nature of this plant offers an opportunity for trial as a potential phytoremediator for a wide range of environmental contaminants some of which had been reported by researchers [12,13] However, little information is available on the survival rate of this specie and its potential as a phytoremediator in spent lubricating oil contaminated soil. Therefore this study aims at assessing the phytotoxicity of spent lubricating oil on Acacia mangium and the phytoremediation potential of the specie in spent oil contaminated soil.

Materials and Methods

Study area

The pot experiment was conducted at the Federal College of Forestry, Ibadan (7o 23'N 3o 51'E) between April and June 2016, the climatic condition of the area is tropical and dominated by rainfall pattern of 1400mm-1750mm with average humidity of about 80 – 85%.

Materials

Spent lubricating oil used to contaminate the soil was obtained from mechanic workshop, seedlings of *Acacia mangium*, polythene pots, paper tape, hand trowel watering cans, and toluene (Analar grade).

Soil sampling and treatment

Topsoil (0 – 15cm) was collected from Teak plantation of the Federal College of Forestry, sieved through 2mm. The growth media was prepared using soil with varying levels of spent oil volume, where T1 (Control, 2kg of the soil + 0ml spent oil), T2 (2kg of soil + 50m, spent oil), T3 (2kg of soil + 150ml spent oil) and T4 (2kg of soil+ 250ml spent oil). The contaminated soils were air dried for 24hrs with representative samples from each treatment pot analysed for Total petroleum hydrocarbon (TPH) before planting and after harvesting.

Determination of total petroleum hydrocarbon

Total Petroleum Hydrocarbon was determined gravimetrically by toluene cold extraction method as described by Adesodun and Mbagwu, [14]. 10g of soil sample was weighed into 50ml flask; 20ml of toluene (Analar grade) was added. After shaking for 30mins on an orbital shaker, the liquid phase of the extract was measured spectrophotometrically at 420nm. The total petroleum hydrocarbon (TPH) in each sample was estimated with reference to standard curve derived from fresh spent lubricating oil with toluene.

Test plant/experimental design

Healthy seedlings of *Acacia mangium* were obtained from the central nursery of Forestry Research Institute of Nigeria (FRIN). The seedlings were transplanted into the prepared pots with different treatments and arranged in a Completely Randomized Design (CRD) and replicated five (5) times. Watering was done daily and data taken

Data collection

Growth parameters like plant height measured using metre rule, stem diameter measured using a vernier calliper and number of leaves produced done by visual count were measured to access the phytotoxicity of spent oil on the test plant. All were measured from two weeks after transplanting.

Total petroleum hydrocarbon of the treated soil samples was also analysed before planting and after harvesting and compared to access the phytoremediation ability of the test plant.

Statistical analysis

Analysis of variance was done to identify significant difference between the treatments in the growth parameters while Duncan test was used to separate the mean. Also student's t-test was done to determine significant difference between TPH in the soil before planting (after treatment) and TPH in the soil after harvesting.

Results and Discussion

Results of pre-planting soil analysis

The pre-planting soil analysis shows a Total Petroleum Hydrocarbon (TPH) of 0.57%, 3.23%, 13.00% and 17.57% for treatments 1, 2, 3 and 4 respectively showing a dose dependent increase in the TPH levels on addition of various volumes of spent oil into the soil, no observable trend was observed in the initial pH of 5.66 (T1), 5.56 (T2), 5.74 (T3) and 5.41 (T4).

Growth parameter

Figure 1 presents the weekly trend observed in plant heights of transplanted *Acacia mangium* seedling as affected by various levels of spent lubricating oil. At the end of eight weeks, no significant difference ($p < 0.05$) was observed in plant heights of all the treatments with treatment 2 (50ml spent oil) having the highest height of 33.50cm and treatment 3 (150ml spent oil) having the least of 27.1cm. This observation is contrary to the findings of Idowu and Fayinminnu [3] where the control shows a significant increase in plant height compared to other treatments in their study of phytoremediation of spent oil using *Jatropha curcas*. This observed difference may be due to the widely documented fact about *Acacia*

mangium being able to thrive in adverse soil condition as similar studies using *Acacia mangium* to phytoremediate heavy metals from sewage sludge follows similar trend observed in this study in terms plant heights [12,13].

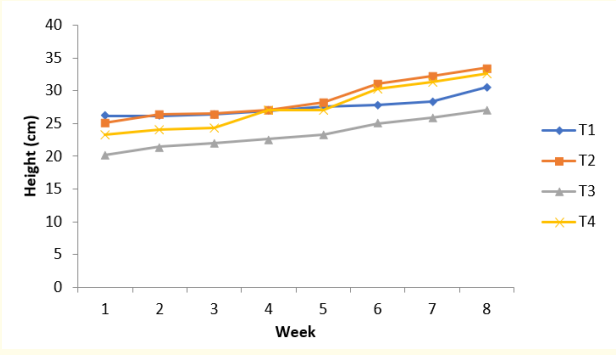

Figure 1: Weekly Trend in Plant Height as Affected by Spent Lubricating Oil.

Figure 2 shows the observed growth trend in terms of stem girth, no significant difference ($p < 0.05$) was observed between the treatments after eight (8) weeks. Treatmen 1 (control) had the highest stem girth of 4.24 while T3 had the least 3.43, thus, spent lubricating oil toxicity may have impacted the stem girth of *Acacia mangium*, albeit not significantly.

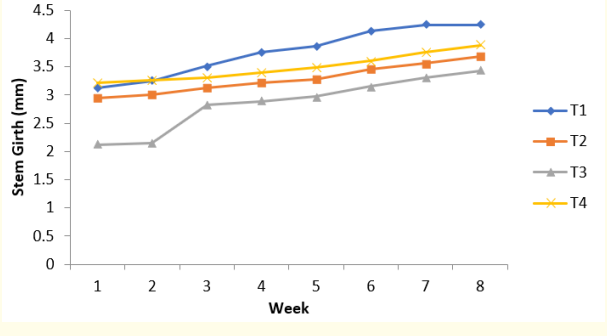

Figure 2: Weekly Trend in Stem Girth as Affected by Spent Lubricating Oil.

From the data obtain for number of leaves (Figure 3), treatment 3 produced the lowest number of leaves after eight (8) weeks which is significantly different ($p < 0.05$) from the other treatments, while treatment 2 significantly produced the highest number of leaves. Treatment 4 produced comparable number of leaves with the control, this is contrary to the findings of [3] where increased dosage of spent lubricating oil caused a reduction in the stem girth of *Jatropha curcas*.

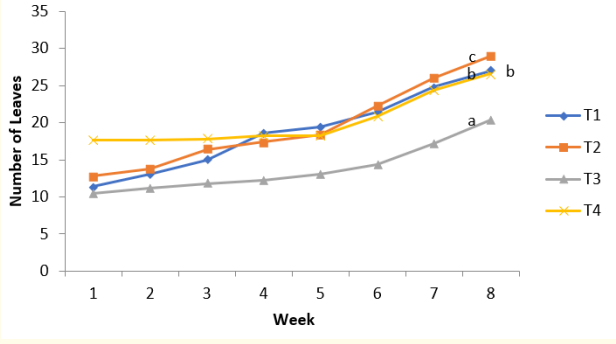

Figure 3: Weekly Variation in Number of Leaves as Affected by Spent Lubricating Oil (Points with same alphabet are not significantly different from each other at $p < 0.05$).

Total petroleum hydrocarbon concentration in growth media

The measurement of amounts of spent lubrication oil in soil was done through quantitative analyses of total petroleum hydrocarbon (TPH) concentration in the soil, the pre-planting soil TPH was 0.57%, 3.23%, 13.00% and 17.57% for Treatments 1, 2, 3, and 4 respectively. At the end of the study, the post planting soil TPH was compared using student's t-test as shown in Figure 4. The results shows a significant difference between the pre-planting soil TPH and post-planting soil TPH across all the treatment, thus, *Acacia mangium* significantly remove 92.98%, 66.56%, 88.85% and 88.73% from T_1, T_2, T_3 and T_4 respectively. This may suggest the potential of *Acacia mangium* to absorb some of the spent oil from the soil.

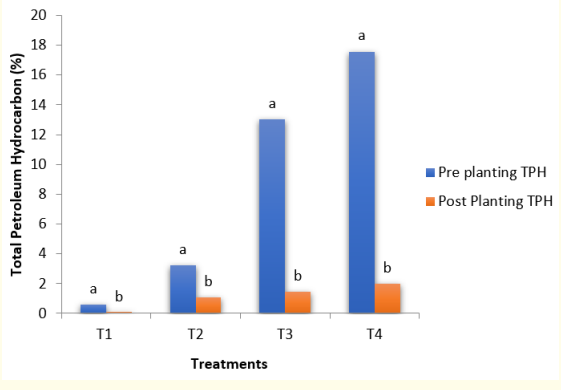

Figure 4: Comparative TPH in Pre-planting and Post-Planting Soil (Complementary bars with same alphabet are not significantly different from each other at $p < 0.05$).

Conclusion and Recommendation

The study has indicated the ability of *Acacia mangium* to survive high level of spent oil in the soil, at the end of the study period. Treatment 2 gave the best response in plant height and number of leaves while Treatment 3 had the least performance in the growth parameters thus, the growth response in this study was not dose dependent as reported by some researchers in previous studies. Total Petroleum Hydrocarbon drastically decreased from the growth media across all the treatment which appears to shows dose dependent removal efficiency.

The study further shows the ability of *Acacia mangium* to withstand adverse soil condition and could thus be a candidate for the phytoremediation of oil spill soils. It is therefore recommended that *Acacia mangium* should be further explored as a good candidate for the clean-up of spent oil contaminated soil, and also, due to the massive removal of soil TPH observed, the role of carbon degrading microorganisms in this process cannot be rule out this, further studies on the microbial degradation alongside plant uptake needs to be evaluated as well as the accumulation of petroleum hydrocarbon in the plant's tissue.

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